ABSTRACT

Tool life can be defined as usable time that has elapsed before the cutting tool has failed to produce acceptable work piece. It has become need of the time to develop more and more wear resistant tool materials or different treatments on existing tool materials so as have more tool life. Cryogenic treatment has proved to be one such treatment, which improves wear resistance of tool steels. This improved wear resistance needs to be evaluated. In the present experimentation one of the newly developed tool steels is used for developing empirical mathematical models to evaluate wear of conventionally and cryogenically treated tools. Literature review for the effects of cryogenic treatment on properties of materials, in general and tool steel in particular indicated that tool steels give better response to cryogenic treatment. Hence a latest tool steel T42 is selected for present research work. Pilot experimentations are carried out for studying effect of cryogenic treatment on T42 tool steel. The samples of T42 HSS are subjected to cryogenic treatment at different temperatures and soaked for different time. The conventionally and cryogenically treated samples are used for turning operations and tool wear of sample tools is measured. The results indicated a good response of T42 tool steel for cryogenic treatment.

Thereafter for main experimentations T42 HSS obtained from a European source is used. A total of 54 Samples are subjected to conventional heat treatment. After heat treatment 42 samples are subjected to cryogenic treatment for different temperatures for a constant soaking time. All tool samples are then ground and provided tool geometry. These tools are used to turn AISI 1018 work pieces on a CNC lathe. Taguchi OA technique is used for deciding number of experiments. Taguchi’s OA method is selected because it incorporates readily available fractional factorial matrices orthogonal arrays to minimize the number of experiments. Taguchi’s modified L$_{48}$ array is used for non cryo tools experimentations and modified L$_{16}$ for cryo treated tools experimentations. After machining, flank wear of the tools is measured with the help of tool maker’s microscope.

The data obtained from non cryo and cryo treated tools experimentations are analyzed using S/N ratio analysis. Confirmation experiments for both the non cryo and cryo treated tools at optimum and one non optimum condition are carried out and tool wear is measured. The graphs are plotted between process parameters and cryogenic temperature verses tool wear.
Empirical mathematical models are developed using regression analysis to evaluate wear of conventionally treated, cryogenically treated T42 HSS tools and improvement in wear resistance due to cryogenic treatment. These models are verified by conducting confirmation experiments. The experimental results, predicted results and results obtained from developed model are in good agreement.

The improvement in wear resistance in case of T42 tool steel due to cryogenic treatment is basically due to conversion of retained austenite into martensite up to $M_f$ temperature and thereafter due to precipitation of fine carbides and refinement of carbide particles in the microstructure, which is clearly observed in microstructure of non cryogenic treated, $-80^\circ C$, $-140^\circ C$, and $-185^\circ C$ cryogenic treated tools taken by SEM. The hardness of conventionally treated T42 HSS after cryogenic treatment practically remained same. This validates that earlier research on other types of tool steel is also applicable to T42 HSS material in context of improvement in wear resistance by application of cryogenic treatment.

Nomographs are very useful and can be used as a ready reckoner for predicting the tool wear by the operator on shop floor. The nomographs are plotted for the both non cryo tools as well as cryo treated tools by using the response data obtained from the experiments carried out.

**Keywords**: Tool life, T42 HSS, Improvement in wear resistance, Taguchi’s orthogonal array, deep cryogenic treatment, Empirical mathematical model, nomograph